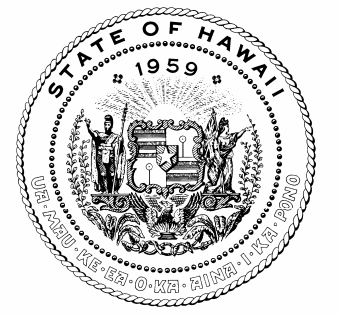
REPORT TO THE TWENTY-FOURTH LEGISLATURE

REGULAR SESSION OF 2007

RELATING TO INVASIVE SPECIES



Prepared by

THE STATE OF HAWAII
DEPARTMENT OF LAND AND NATURAL RESOURCES
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In response to House Concurrent Resolution 11, House Draft 1
Regular Session of 2006
Honolulu Hawaii
November 2006

RELATING TO INVASIVE SPECIES

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PURPOSE

This report complies with House Concurrent Resolution (HCR) 11, House Draft (HD) 1, adopted during the 2006 Regular Session, and covers the proposed actions of the Hawaii Invasive Species Council to address interisland pest movement, green waste and interisland treatment to reduce the spread of invasive species.

"BE IT RESOLVED by the House of Representatives of the Twenty-third Legislature of the State of Hawaii, Regular Session of 2006, the Senate concurring, that the Hawaii Invasive Species Council is requested to:

(1) Investigate and recommend strategies to avoid accidentally spreading coqui frogs and other invasive species through the intraisland and interisland movement of agricultural products;

(2) Investigate the movement of greenwaste and develop one or more statewide protocols to prevent greenwaste from becoming a pathway for the movement of coqui frogs and other invasive species; and

(3) Report on the feasibility of installing intraisland and interisland treatment facilities for agricultural products, and include a budget, to provide a tool to prevent the movement of coqui frogs and other invasive species; and

BE IT FURTHER RESOLVED that the Hawaii Invasive Species Council is requested to consider, in relation to the protocol for greenwaste movement, strategies, including but not be limited to:

(1) Not moving any greenwaste off of sites where the invasive species has been identified;

(2) Developing county-level lists of invasive species that may be moved in greenwaste;

(3) Developing treatment protocols for each priority species that will be carried out by the agency generating or transporting the greenwaste prior to the waste being moved off site;

(4) Developing maps for species that may be moved locally via greenwaste and monitoring protocols for all regularly used greenwaste recipient sites for all county-level priority species;

(5) Identifying the party responsible for treating new infestations when priority invasive species are identified at the recipient sites;

(6) Prohibiting state or county agencies from authorizing, funding, or carrying out any action that would likely cause or promote the introduction or spread of coqui frogs and other invasive species in Hawaii or to other states, territories, or Pacific islands; and

(7) Requiring all state and county agencies to consider interdiction issues when planning any activity that may cause the accidental introduction of coqui frogs and other invasive species to uninfested areas in Hawaii, other states, territories, or Pacific islands; and

BE IT FURTHER RESOLVED that the Hawaii Invasive Species Council is requested to research and report on the information gathered from case studies and economic analyses conducted by the Department of Economics at University of Hawaii Manoa; and
BE IT FURTHER RESOLVED that the Hawaii Invasive Species Council is requested to report its findings and recommendations, including any proposed legislation, to the Legislature no later than twenty days prior to the convening of the Regular Session of 2007

BACKGROUND

The State of Hawaii will always be burdened with invasive species prevention and control. The State needs to see that the latest technology and science is applied to assure actions are timely, effective and efficient. Public funding from the State of Hawaii alone cannot support all the efforts needed. It requires a concerted, cooperative effort.

An integrated action and funding plan that incorporates contributions from the County, State, Federal and private industry sources is needed to provide focus and fiscal resources for the ongoing invasive species prevention and control programs.

Furthermore, authorities for preventing and controlling invasive alien pests are spread across numerous state and federal agencies, making close coordination of activities among these agencies imperative.

Investments are needed in prevention, early detection and rapid response programs. Invasive species are controlled most efficiently and effectively, and at the lowest cost, early in the invasive process.

Hence, money that provides effective quarantine barriers to prevent invasive species from arriving and which provides rapid response teams to stop pests from becoming established should be the highest priority of the State in addressing alien invasions at this time.

The 2003 State Legislature authorized the creation of the Hawaii Invasive Species Council (HISC) and stated “the silent invasion of Hawaii by alien invasive species is the single greatest threat to Hawaii's economy, natural environment, and the health and lifestyle of Hawaii's people and visitors.” Hawaii is one of the four states in the Nation that has recognized the need for coordination among all state agencies, at a cabinet level, that have responsibility to control invasive species on the ground, as well as regulate or promote the pathways in which invasive species can gain access into the state.

HISC members include the chairs or directors of the Departments of Land and Natural Resources (DLNR), Agriculture (DOA), Business, Economic Development, and Tourism (DBEDT), Health (DOH), Transportation (DOT) and the President of the University of Hawaii (UH), additionally Directors from the Departments of (Hawaiian Home Lands (DHHL), Commerce and Consumer Affairs (DCCA) and Defense (DOD) have been

invited to participate. HISC provides the institutional framework for leadership and coordination for a statewide invasive species prevention and control program.

Support for HISC is provided by working groups as described in the State of Hawaii Strategic Plan for Invasive Species; Prevention, Control, Research and Public Outreach. HISC participating agency staff cooperatively identified the goals for the Working Groups that represent key aspects of a comprehensive program. The specific tasks listed are derived from the enabling legislation and from suggestions by Coordinating Group On Alien Pest Species (CGAPS) members. These tasks have not been reviewed or prioritized by the working groups and it is expected that the specific tasks will change over time as progress is made in achieving the stated goals.

The working group tasked with focusing on pests not present in Hawaii as well as intrastate quarantine issues is the Prevention Working Group. The description of this working group as well as the members, goals and tasks from the state plan are as follow:

HISC Working Group on Pests Not Present in Hawaii - (Prevention)

(Lead HISC Member: DOA. **Participating HISC members:** DLNR, DOT, DOH, UH, DCCA, DOD, Counties**)**

Goals: (1) Review risks of pest entry into the State and to assist in the setting of priorities to prevent entry of high-risk pests; and (2) Determine how best to prevent the entry of new pests with shared resources and shared responsibilities of all agencies.

HISC Prevention Working Group Tasks:

- Incorporate and expand upon the State's weed risk assessment protocol to the extent appropriate for the HISC's invasive species control and eradication efforts
- Identify and record all invasive species present in the State.
- Reprioritize inspection and quarantine services for goods imported to the State based on new data provided by the Kahului Airport Pest Risk Assessment.
- Identify high priority pest species for which there is a high risk of introduction to Hawaii and develop monitoring and rapid response plans.
- Request Animal and Plant Health Inspection Service (APHIS) to screen domestic traffic into Hawaii for living plant material (similarly to the screening that takes place between Hawaii and the mainland now).
- Develop a comprehensive "approved planting list" to ensure that no invasive species are being planted in State projects or by any state contractors. The plants on the list should be screened by the Weed Risk Assessment protocol.

- Identify specific improvements to quarantine inspection of domestic cargo and passenger arrivals at Hawaii ports.

- Support legislation to protect against introductions of brown tree snakes and other snakes from entering Hawaii.

- Develop a comprehensive and timely invasive species listing process fro use by all state agencies.

- Review the structure of fines and penalties to ensure maximum deterrence for invasive species-related crimes.

- Identify species that are at high risk of being introduced to the State or being spread within the State by illegal trade.
- Coordinate and promote the State's position with respect to federal issues, including:
    - Quarantine preemption**;**
    - International trade agreements that ignore the problem of invasive species in Hawaii;
    - First class mail inspection prohibition;
    - Whether quarantine of domestic pests arriving from the mainland should be provided by the federal government;
    - Coordinating efforts with federal agencies to maximize resources and reduce or eliminate system gaps and leaks, including deputizing the United States Department of Agriculture's (USDA) plant protection and quarantine inspectors to enforce Hawaii's laws;
    - Promoting the amendment of federal laws as necessary, including the Lacey Act Amendments of 1981, Title 16 United States Code sections 3371-3378; Public Law 97-79, and laws related to inspection of domestic airline passengers, baggage, and cargo;

SUMMARY OF ACTIONS RELATED TO HCR 11 HD1

Investigate and recommend strategies to avoid accidentally spreading coqui frogs and other invasive species through the intraisland and interisland movement of agricultural products.

The mechanisms and routes that spread invasive species generally referred to as pathways. These pathways are numerous and the risk that an invasive species will be moved depends both on the species in question as well as the pathway. A current effort by USDA at the request of DOA and the Hawaii delegation has identified the following pathways into the State of Hawaii. These pathways are likely to be important in the movement of pests within the State as well:

General Public
I. Air

A. Commercial aircraft (passenger airlines, parcel shippers [e.g., UPS, Federal Express])
    1. Passenger baggage
    2. Cargo
    3. Mail
    4. At large (e.g., free-flying insects)
    5. Stores or supplies
    6. Garbage
B. Private aircraft
    1. Baggage
    2. At large
    3. Stores or supplies
    4. Garbage

II. Sea
A. Commercial shipping
    1. Passenger baggage
    2. Stores
    3. Cargo (commercial and private goods)
    4. Mail
    5. Ballast
    6. At large
    7. Garbage
B. Private vessels (e.g., yachts, Hawaiian Voyaging Society canoes)
    1. Stores
    2. Baggage
    3. At large
    4. Garbage

Military

I. Air
A. Aircraft
    1. Baggage
    2. Vehicles and machinery
    3. Supplies or equipment
    4. At large
    5. Stores
    6. Garbage
    7. Cargo (including private goods)

II. Sea
A. Naval vessels
    1. Stores
    2. Baggage
    3. Vehicles and machinery
    4. Supplies or equipment
    5. At large
    6. Garbage

7. Ballast
8. Cargo (including private goods)

ORGANISMS POTENTIALLY INVADING AND MODE OF ENTRY

I. Arthropods
- A. On, in, or with commercial commodities
  1. Fresh fruits & vegetables
  2. Dry goods or processed food (e.g., rice, flour)
  3. Nursery stock (including houseplants)
  4. Seed
  5. Cut flowers
  6. Raw materials (e.g., building supplies, timber)
  7. Finished or manufactured goods (e.g., furniture, appliances)
- B. Smuggling
- C. Private household goods (civilian or military)
- D. Pet trade (e.g., ant farms, pet food [mealworms, bloodworms])

II. Molluscs
- A. On, in, or with commercial commodities
  1. Fresh fruits & vegetables
  2. Nursery stock
  3. Cut flowers
- B. Smuggling

III. Pathogens (including nematodes)
- A. On, in, or with commercial commodities
  1. Fresh fruits & vegetables
  2. Dry goods or processed food (e.g., rice, flour)
  3. Nursery stock (including houseplants)
  4. Seed
  5. Cut flowers
  6. Raw materials (e.g., timber)
- B. Smuggling
- C. Contamination of personal effects or clothing (e.g., spores on muddy boots)

IV. Plants
- A. Commercial commodities
  1. Nursery stock (including houseplants)
  2. Seed
- B. Smuggling
- C. Contamination of personal effects or clothing (e.g., seeds on muddy boots)

V. Vertebrates
- A. Pet trade
  1. Fish
  2. Reptiles and amphibians

B. Nursery stock
    1. Amphibians (e.g., coqui)
C. Smuggling
    1. Reptiles (e.g., Tokai gecko, Jackson chameleon, iguana)
D. Stowaways on aircraft
    1. Reptiles (e.g., brown tree snake)

VI. Marine organisms
A. Pet trade
    1. Invertebrates
    2. Fish
B. Ships' hulls
    C. Ships' ballast water

<u>Action:</u> The Administration is evaluating including a request to restore HISC funding in Fiscal Year (FY) 08 to allow DOA to carry out risk assessments that will identify which pathways pose the greatest risk of moving priority invasive species within the State.

The new DOA Biosecurity initiative from FY 2006 will provide up to $2,900,000 and 56 new temporary positions for the Department to improve quarantine inspections. The success of this increase was based in part on the risk assessments and research inspections carried out with $1,698,000 in HISC funding from FY 2005 and 2006.

The research and subsequent Biosecurity program are focused on preventing the establishment of new pests into Hawaii. To evaluate the risk of interisland and intraisland pest movement additional risk assessments are needed to identify which of the pathways listed previously pose the greatest risk and can be mitigated by inspections, new rules and protocols and better port infrastructure. New operators such as the Hawaiian Superferry which will dramatically increase the movement of personal vehicles and private cargo interisland will change this risk landscape.

At this time, there are no operating funds designated for HDOA that could be used to carry out this study and evaluate the risks associated with moving pests interisland and develop a strategy for reducing risk of interisland pest movement

Another important component of reducing interisland and intraisland invasive species spread is the ability to detect newly established pests and respond quickly to eradicate them island wide. The capacity to carry out this "early detection and rapid response" has been broadened and improved by the Island Invasive Species Committees (ISC).

<u>Action:</u> The HISC Research and Technology Grant program funded a pilot project to create a voluntary"Coqui-free" certification program for the Island of Maui.

This project has recently been initiated via contract so results are not yet available. Project outline from the Contract:

1. Develop and implement a "Coqui-free" Certification Program on the Island of Maui, to include the following components:
   - Participation will be available to any commercial plant provider on Maui. Industry members will be asked to participate in development of standards.
   - Adherence to specific protocols designed to ensure that no frogs are introduced to the participant's site.
   - Adoption of specific practices to ensure that infested plant material is not distributed from the site.

2. Include the following information components about the certification program:
   - Targeted outreach to industry members across market segments based on: size, geography and place in the distribution chain (grower, wholesaler, retailer).
   - Marketing materials for businesses to indicate participation and certification.
   - Inclusion of information about participants on MISC website.
   - Outreach via press releases, public service announcements and other appropriate media.

3. Develop and Implement market incentive and consumer behavior surveys to include the following:
   - Randomly select members of the industry from a comprehensive list of businesses and classify them as high or low volume according to number of sales per year.
   - Design and conduct pre- and post-program implementation questionnaire surveys to determine current practices to prevent establishment of coqui frogs.
   - Conduct pre- and post-program implementation physical surveys of the sites to assess current practices.
   - Conduct pre- and post-program implementation surveys to evaluate consumer awareness of the coqui frog problem, awareness of the certification program, and purchasing behavior.

4. Analyze the data to determine statistical significance and assess the impact of the program.

<u>Action:</u> DLNR's Division of Forestry and Wildlife and USDA National Wildlife Research Center in Hilo published Hawaii's Coqui Frog Management, Research and Education Plan and presented the draft to HISC on July 18, 2006.

From the Executive Summary:

A. STATE OBJECTIVE

The coqui frog, *Eleutherodactylus coqui*, threatens the stability of Hawaii's native forest ecosystems. High densities of the coqui frog have become a serious noise nuisance in residential and tourist areas and are also decreasing property values. Vendor and public concern over purchasing infested nursery material is impacting the floriculture and nursery products industry. In 2006 alone, the State Legislature allocated over $1.8 million for the control of coqui frogs. The full ecological and economic impact of the frog has yet to be determined, but the severity of the invasion requires the development

and implementation of a coordinated management plan. The objective of the Statewide Management Plan for the Coqui Frog is to provide a comprehensive summary of the status of the invasion, outline possible options, evaluate the costs and consequences of different options, and provide recommendations for future action.

Options under consideration range from "No Action" to eradication of the species from all known locations. Eradication is an option which is highly attractive theoretically, but not so easy in practice (e.g., Hobbs and Humphries 1995; Mack and Lonsdale 2002; McNeeley, Neville and Rejmanek 2003). Myers and Ware (2002) point out that the opportunity for eradication is often lost by the time the problem is recognized and control projects are considered or actually implemented. Because it is possible to restrict the movement of organisms between the main islands through quarantine practices, the containment of invasive species that are widely established on one island to protect the remainder of the State can help to limit the damage caused by this invasion. Efforts to eradicate or contain defined infestations may be spearheaded by local community groups or managed entirely by government entities.

In addition to addressing a suite of options for action, this Plan recognizes that there are significant differences among the Hawaiian Islands in terms of distribution, abundance, rate of spread, control efforts, and level of involvement by government agencies and local communities. For instance, coqui frogs are not known to be present on Lanai, Molokai, or Kahoolawe. Multi-agency efforts since 2000 have reduced the populations on Kauai and Oahu and eradication is feasible with current tools and resources. On Maui, successful control efforts at eleven population centers have significantly reduced frog densities, but control at one large infestation has not been addressed. On the Big Island, island-wide eradication may no longer be feasible, but geographically-defined areas could be contained. These differences as well as level of control are described in the island-specific sections of the Plan. Where there is uniformity among islands in terms of apparent options, a single summary has been provided.

B. MANAGEMENT GOALS WITH SELECTED ALTERNATIVES

Statewide

The preferred alternative would be to restrict the spread of frogs into new habitats, eradicate small discrete populations in high-value natural areas, and eradicate frogs from the Islands of Oahu and Kauai. These management efforts should be combined with increased public education and outreach for all islands. To reduce the spread of frogs, detection activities should increase statewide, quarantine systems should be established that minimize the risk to intrastate and via out-of-state exports, and effective protocols should be enacted for movement of materials among islands. Local communities and businesses that are actively suppressing local coqui populations should be supported. All information on the distribution of frogs and the efficacy of control efforts should be centrally maintained.

Oahu
The alternative for increased control would ensure that current progress on eradication of all known populations of coqui frogs is maintained as well as ensuring that no new populations become established. Increased public education would result in improved reporting and subsequently more effective response to new populations.

Big Island
Even if no additional resources are made available, efforts to maintain information on the distribution of coqui and the efficacy of control efforts should be improved. Establishing more effective protocols to prevent spread of frogs intra-island will result in preventing the costs associated with mitigation and control for other counties. Efforts should be made to eradicate or contain frogs in geographically-defined areas on the Big Island, including outlying populations, high-value natural areas, and sites that would facilitate further distribution. Continuing support to local communities and businesses that are actively suppressing local coqui populations by providing education, training and material support is a priority.

Kauai
The alternative for increased control would ensure that current progress on eradication of all known populations of coqui frogs is maintained as well as ensuring that no new populations become established. Increased public education would result in improved reporting and subsequently more effective response to new populations.

Maui
The alternative for increased control would ensure that current progress on eradication at most known smaller population centers of coqui frogs is maintained. Containing the Maliko Gulch population and work toward eventual eradication is preferred but unlikely to succeed with current resource levels. Increased public education would result in improved reporting and subsequently more effective response to new populations. Adding additional inspectors may be possible with the new DOA Biosecurity initiative which could provide adequate inspection of incoming plant materials for Molokai and Lanai.

C. RESEARCH GOALS WITH SELECTED ALTERNATIVES

Control
Current chemical control methods may be used in agriculture, private lands, and natural areas. Additional chemical control methods could be developed to target frogs in natural areas or to be used in quarantine areas for sensitive plants. Barriers and hot water methods may be useful in quarantine areas or greenhouses and development of effective methods seems likely. State funding should be centralized with HISC so duplication of effort and research into unproductive areas is minimized. HISC's process of providing research funds is well established and ensures peer review of research endeavors. Since funding was reduced from $4,000,000 in 2005 and 2006 to $2,000,000 in FY 2007, it is not clear if there will be continued support for the HISC research program. Funds

provided to DOA and other entities should follow a similar framework to ensure high quality research.

Effects of Frogs
Increased state funding should be directed to research on the economic effects of frogs to document the impact and reveal areas of concern. Funding for the effects of control efforts should be a high priority to ensure that goals for each island are being met.

D. EDUCATION AND OUTREACH WITH SELECTED ALTERNATIVES
Education and Outreach activities should be increased statewide to present a unified and comprehensive focus on this pest. This will require additional resources to increase participation and awareness. Current levels of resources are inadequate to encourage reports of new coqui locations, provide responses to calls that do come in or train community members to respond to populations of coqui in their neighborhoods. More could be done to reach the plant industry. The plant industry mailing database has recently been completed and numbers up to 3,000 entries statewide. Education for homeowners/residents should continue to use the major media outlets on the islands, but to increase the frequency of the messages. Additional materials should be developed and disseminated for all relevant media, including television, newspaper, radio, and internet to educate the public about the magnitude of the coqui frog problem, how to take appropriate action, and the status of detection and control efforts. Public assistance in detecting and reporting frog locations is essential.

The incorporation of the statewide 643-PEST hotline with appropriate follow up is critical. To encourage public cooperation, reports must generate a timely and meaningful response from a central response center. This central response center for inquiries and reports from the public should field and answer questions from the public and take information about new infestations as well as inform reporters about planned activities for the area and how the reporter can help. Developing a response follow-up tracking system and central database will maintain adequate communication among cooperators.

E. FUNDING NEEDS AND SOURCES
Current funding levels are not sufficient to achieve statewide eradication of coqui frogs. Continued control efforts funded by state and federal sources on Kauai and Oahu will result in the likely eradication of all known populations of coqui on those islands. It is unlikely that the current resources available for surveying for coqui and providing outreach to encourage businesses and the public to report new locations of coqui are adequate to ensure the individuals and small populations are detected rapidly enough to eliminate the need for a continuing response capacity. Current state and county funding for Maui County efforts will result in a reduction in the number of populations of coqui frogs but will not fully contain the large population at Maliko Gulch. Current efforts on the Big Island may slow the spread of coqui from some isolated populations but does not address spread from large population centers, the impact of coqui to nurseries and other businesses, most new isolated populations or many of the requests from the public for assistance.

Selective alternatives would provide for increased survey, detection and outreach efforts on Kauai and Oahu, increased control on Maui and more support for the Big Island communities. Another critical element that will reduce future costs is investment in improved interisland quarantine and interdiction. A stronger investment in research would require additional funding over and above the current efforts from local, state and federal funding agencies. Overall, cost estimates are based on current knowledge. Prices may decrease if additional tools or methods are developed or prices may increase due to increased costs.

<u>Action:</u> DOA is currently in the process of administrative rule amendments to Chapter 4-72 which would establish rules for restricting the movement of propagative plant material within the state that may be infested with coqui.

From the DOA Plants and Animals Committee Submittal:
On September 27, 2001, the Board of Agriculture designated coqui frog a pest under Section 150A-2, Hawaii Revised Statutes (HRS). Section 150A-2 defines a pest as any animal, insect, disease agent or other organism in any stage of development that is detrimental or potentially harmful to agriculture, or horticulture, or animal or public health, or natural resources including native biota or has an adverse effect on the environment as determined by the board. The board's designation of the coqui frog as a pest under section 150A-2, HRS, provided the department with the authority to stop interisland shipments infested with coqui frogs and to require treatment of infested shipments. Currently, infested status is determined by visual inspection.

Since that time, the coqui problem has grown exponentially. In 2001, there were eighty-five documented occurrences of coqui populations. Now, there are over one hundred fifty firmly established infestation sites on the island of Hawaii. The islands of Maui, Kauai, and Oahu are also partially infested. Single coqui frogs were retrieved on the islands of Molokai and Lanai, but there are no established populations as yet. Federal, state and county funding has contributed well over one million dollars to the coqui eradication effort and more is needed in the future.

Amendments to the Chapter 4-72, HAR, and related rule chapters, are the most effective means of preventing the further spread of coqui within the island of Hawaii and to other islands in the State. Because the frog and its eggs are difficult to detect, visual inspection alone cannot prevent the spread of the coqui to uninfested areas. The Plant Quarantine Branch proposes to restrict the movement of plants and propagative plant parts because the movement of these plants and propagative plant parts are high risk for the spread of the coqui frog.

The proposed amendment will prohibit movement of plants and propagative plant parts, except for the following exceptions: 1) one hundred percent inspection for non-commercial shipments not exceeding twelve plants that are washed free of media; 2) shipments from certified nurseries provided that the shipments are accompanied by a declaration certifying the shipment free of coqui or a declaration certifying approved

treatment for coqui; and 3) any other shipment, provided the plants are treated with an approved treatment.

The proposed amendments also prohibit the intraisland movement, sale, offer for sale, transfer or transport of plants harboring coqui frog from an infested area to a non-infested area.

4-72-X Restrictions on the movement of propagative plant materials that may harbor or be infested with the coqui frog. (a) The interisland transportation of plants and propagative plant parts that may harbor or be infested with the coqui frog (Eleutherodactylus coqui) is prohibited except for:
(1) Non-commercial shipments of plants introduced in lots not exceeding twelve plants, provided that the plants are washed free of media, subjected to one hundred percent inspection, and found free of coqui frogs.
(2) Shipments from certified nurseries, provided that the shipments are accompanied by a declaration certifying the shipment or shipments are coqui free or certifying that the shipment has undergone an approved treatment for coqui.
(3) Shipments that do not meet the requirements of paragraphs (1) and (2) must be treated with an approved treatment prior to interisland movement.
(b) The intraisland movement, sale, offer for sale, transfer or transport of plants harboring coqui frog from an infested area to a non-infested area is prohibited. (Auth: §§ 141-2, 150A-9) (Imp: HRS §§ 141-2, 150-8)

Unfortunately these restrictions will not require treatment unless a coqui is found. As these animals are very small, detection is unlikely and 100% treatment would provide a higher level of protection. Treatment of all plants leaving the Big Island would resolve the issue that the status of a nursery may change rapidly from uninfested to infested given the larger and expanding populations of coqui present.

***Action:* On January 19, 2006, HISC adopted a resolution that departments use all existing authorities to stop the spread of coqui (Eleutherodactylus coqui) intraisland, interisland and to other locations outside the State of Hawaii and develop authorities and protocols to fill the current gaps.**

The text from the submittal to HISC was as follows:

BACKGROUND:
Presently, conservative estimates are that the large population of coqui on the Big Island near Hilo is approximately 5000 acres. As current tools do not allow for the eradication of such a large population, developing a strategy for containment that includes cooperative action is required to prevent the spread of coqui from infested areas to uninfested areas.

One critical element is that all partner agencies need to improve communication and clarify authorities to meet the goal of no coqui on Kauai or Oahu, containment on Maui with eradication at all nursery and isolated population sites, and suppression on the Big

Island with long term, enforceable treatment regulations that will ensure that frogs are not moved interisland. The Invasive Species Committees (ISCs) have made excellent progress towards eradication on Kauai and Oahu with containment on Maui and support for Big Island community efforts. Since the ISC's are partnerships that allow the participating agencies to effectively execute their authorities it is critical that the agencies consistently exercise their existing authorities to allow for the successful completion of control efforts.

CURRENT REGULATIONS

The following is a summary of applicable DLNR and HDOA laws and regulations. A 1998 MOU also states that DLNR will address alien species on state lands and HDOA will address alien species on private lands and that they will cooperate and extend their authority to the other agency when cooperation is not possible.

DLNR:

Hawaii Administrative Rules (HAR) 13-124-3(d) provides:

> With respect to injurious wildlife, except as provided in subsection (e), no person shall, or attempt to:
>
> (1) Release injurious wildlife into the wild;
> (2) Transport them to islands or locations within the State where they are not already established and living in a wild state;
> (3) Export any such species, or the dead body or parts thereof, from the State.

Exhibit 5 – Injurious Wildlife, Chapter 13-124, includes "Frogs - All species in the Order Anura". The Order Anura includes all frogs and toads.

This established that DLNR has authority to control coqui frogs on State lands and impose penalties when intentional transportation of injurious wildlife is documented.

DOA:

The coqui has been designated as a pest under HRS 150A-2: "Pest" means any animal, insect, disease agent or other organism in any stage of development that is detrimental or potentially harmful to agriculture, or horticulture, or animal or public health, or natural resources including native biota or has an adverse effect on the environment as determined by the board. This designation allows HDOA to take action on infested intrastate (interisland) plant shipments.

GAPS IN AUTHORITIES

Currently, there are no rules associated with the authority in Act 85 2003 for access to private lands for the purpose controlling invasive species. Developing rules for access specifically for coqui should be made a high priority.

Because the primary mode transportation of coqui is infested plant materials and current regulations focus on intentional movement of the coqui themselves or require the visual detection of a coqui in materials prior to treatment, agencies are not able to adequately regulate this pathway. Requiring a treatment prior to the movement of materials that may harbor coqui would reduce the risk of transporting coqui as well as identifying the need to address materials that are likely to be infested.

RECOMMENDATION:
That the Council resolves to support the adoption of the following policy:

"All existing authorities to stop the spread of coqui (*Eleutherodactylus coqui*) intraisland, interisland and to other locations outside the State of Hawaii will be exercised. Where gaps exist, all agencies will work cooperatively to develop authorities and protocols to stop the spread of coqui."

***Action:* The local "Stop Coqui" project by the Kohala Coqui Coalition and the HDOA is working to develop intraisland protocols to limit the movement of coqui frogs on the Island of Hawaii.**

From the Kohala Coqui Coalition report to HISC on the status of their HISC funded outreach projects from FY 2005 and FY 2006:

What is the Kohala Coqui Coalition (KCC)?

> KCC is a group of about twenty local residents who have come together to eradicate coqui infestations and to mount an educational campaign to prevent further infestations in the community.

What's being done about the infested areas in North Kohala?

> Coquis in all reported infestations (about twenty-five locations) in North Kohala have been treated, and of these, we are sure that that at least 18 of these have been eradicated. The Coalition is monitoring those infestation areas where eradication is not yet certain to detect any noise-making adults. These monitoring efforts will continue for approximately another seven months to insure that all eggs have hatched and all frogs have been removed. We currently receive about two coqui reports a month on our Coqui Hotline — 889-5775.

Why do you have to keep checking coqui infestation sites?

> One eradication often does not stop coqui frogs. Coqui in the wild lay their eggs in hidden or protected spots that are often difficult to treat during eradication efforts. If missed, the eggs will hatch and the small immature frogs, which do not make coqui calls, are very difficult to see in the brush or in trees. Hatched male frogs take about nine months to begin to make noise. So we need to continue to check all sites until we can confirm that no males frogs are calling. At this point we can be fairly sure that all coquis have been eradicated.

How can I keep Coqui frogs out of North Kohala?

The best way to keep coquis out is DON'T BRING PLANTS INTO NORTH KOHALA! Many Big Island plant nurseries (except those in North Kohala), as well as all plant retailers including Home Depot, Wal-Mart, and Kmart, may be infested with coqui. Be especially cautious with landscapers who buy their plants from wholesalers outside of North Kohala. Obtain plants in North Kohala. Make sure neighbors know about this threat. Signs on Akoni Pule Highway and the mountain road are positioned to remind residents to check incoming plants for coqui and coqui eggs. Efforts by some retailers, like Sunrise Nursery in Kona, to become coqui free are paying off, but plant buyers should always ask about coquis before they buy, and check their plants before entering North Kohala. If you have any doubt, we strongly recommend that you quarantine your plants in-doors until treated.

Are there ways to treat plants?

To eradicate coqui in potted plants, spray the plants with a citric acid solution. Mix 2 3/4 cups per gallon. This will kill frogs and eggs. Spray the root ball, and search for and destroy eggs in the pot. To avoid damaging sensitive plants, rinse with cold water an hour after spraying. Dry citric acid for mixing may be purchased at Sunshine Hardware.

You may also spray plants and roots with hot water, at least 113º F for 5 minutes, which will also kill the frogs and eggs. Catch and destroy any frogs that jump out of the plants. Frogs are nontoxic and may be caught and handled by hand.

Hydrated lime, a readily available agricultural product, has recently been approved for use against coquis. Lime should be mixed with water to avoid toxic dust. In dry weather, spreading lime under infested trees kills frogs when they come to the ground during the daytime.

What should I do if I hear Coqui frogs in my neighborhood?

First try to make sure you are hearing a coqui. Several kinds of crickets may at first sound like coqui frogs, but only coqui make the extremely loud calls at night. Once you think you have a coqui, call the local Coqui hotline — 889-5775 — and KCC will arrange for an experienced coqui squad to visit your area, verify that you have an infestation, and, if so, work with you and the neighborhood to eradicate it.

Is there a charge for eradications?

So far, we have not charged for our services. We accept tax-deductible contributions from landowners who benefit from our services, and hope that this approach, designed to encourage coqui reporting, will continue to work. Should the number of infested areas increase dramatically in the coming months, we will have to reexamine this approach.

Is there a way to catch frogs on my property?

Some experienced coqui busters are able to catch coquis by hand. This is not very easy to do. However, success with PVC traps is being reported from many groups

around the Big Island. These traps are described in the box below courtesy of the University of Hawaii.

What is being done to make nursery plants on the Big Island coqui-free?

Although laws pertaining to transporting coqui intra-island have not yetbeen enacted, current enforcement efforts are being increased to address this problem. Currently, all shipments, both inter- and intra-island, from two Big Island nurseries known to have coqui infestations are being checked by the State.

Most importantly, interest is mounting among the Big Island nurseries association and the State and County to investigate a coqui free program for plant vendors.

KCC has prepared a detailed overview of a Coqui Free Program, and we are proposing this program for the Big Island. The final program would be designed by a planning and implementation group made up of representatives from the County Mayor's office, the Hawaii Department of Agriculture, the Big Island Association of Nurserymen, the Hawaii Association of Landscapers, and the Big Island Invasive Species Committee.

We will present this proposal to the Big Island Coqui Working Group, a comprehensive group of experts fighting the coqui invasion, in April seeking their endorsement to proceed with detail plans for approval, hopefully in late summer of this year. So far, all members of the above groups appear willing to work on this project to overcome issues and find a way to create a non-regulatory solution to plant sales intra-island. If implemented, the program will publish a list of coqui free plant vendors — including nurseries, retailers, landscapers and other types of businesses that sell plants — so that consumers and commercial purchasers alike can have full knowledge of where to buy coqui free plants.

The program would also help nurseries and other vendors with major coqui infestation by offering matching fund grants to complete eradications in the nursery. We hope this program will significantly reduce the coqui threat to North Kohala. In the meantime, continued consumer vigilance and pressure will help all retailers see the importance of taking action.

What are the State and County doing to help?

The Hawaii Invasive Species Council was created by the State Legislature to increase the attention and focus on controlling invasive species like the coqui. Funds to fight coquis have been budgeted by the state, and last year Mayor Kim declared a state of emergency on the island's coqui frog infestation. Last April, the state legislature appropriated $100,000 to help eradicate coquis on the Big Island, and in May KCC received a $5,300 grant from the Hawaii Invasive Species Council to educate the community about coquis in North Kohala. We recently were rewarded another $6,000 to help continue our education program next year and $5,000 from the Country for eradication. In July, Representative Dwight Takamine and Billy Kenoi, Mayor Harry Kim's aide, attended a special

meeting in Hawi to lend support to the Coalition and to listen to local resident's concerns. Clearly the message about the threat of coquis is being heard in Hilo and Honolulu.

In the current state legislature convened in January, no less than five bills or resolutions have been introduced by what the Honolulu Advertiser called "coqui crusaders" in the legislature. Our representative, Dwight Takamine, is at the forefront of this effort. One of the bills calls for $2 million in state funds to pay for an anti-coqui action plan on the Big Island, and another resolution in the package calls on the federal government to put up money for the coqui eradication effort.

However, a study published last year on the impact of the coqui concluded it is unlikely that coquis will ever be eradicated on the Big Island and Maui.

Last October, Peter Young, from Waimea, now the Chairman of the Division of Land and Natural Resources, is quoted as agreeing that coquis will probably never be wiped out on the Big Island. These comments have "disappointed", if not seriously irritated many Big Island coqui fighters at the local and country level. State Representative Clifton Tsuji from Hilo said he believes we can conquer coquis. "This is not an impossible dream, this is Mission Possible."

Mayor Harry Kim has acknowledged that many volunteer community coqui fighters have been frustrated with the slow, or no, response by the County during the past decade. "I make no bones about it, I'm sorry we are where we are today," he said at a recent coqui meeting.

Are stricter regulations concerning inter– and intra-island shipments of plants being considered?

Yes. In December 2005 the state Department of Agriculture issued a policy concerning all inter-island movements of plants from islands infested with coqui frogs. These regulations provide procedures for carefully inspecting for coquis and certifying or rejecting all plant shipments to other islands from the Big Island. These rules are being implemented now in meetings around the island.

In the opinion of some, this policy on inter-island shipments amounts to a virtual quarantine of all plant material leaving the Big Island destined for neighbor islands, although it is not called a quarantine in the policy.

Although this policy does not address intra-island shipments, a document from the Department of Agriculture does discuss two prevention options. One proposes that all intra-island shipments of plants infested with coquis not be transported to other parts of the island that are not infested without being treated to exterminate the coquis. The second option proposes a quarantines of all nurseries infested with coqui and prohibiting movement of plants from these nurseries to all areas of the state not known to be infested.

Serious challenges, difficulties, and consequences to both of these two options are also listed. It is unknown at this time whether either of these options are being seriously considered for implementation.

Investigate the movement of greenwaste and develop one or more statewide protocols to prevent greenwaste from becoming a pathway for the movement of coqui frogs and other invasive species;

There has been no action yet for this request but the following strategies will be considered by the HISC Prevention Working Group for consideration:

BE IT FURTHER RESOLVED that the Hawaii Invasive Species Council is requested to consider, in relation to the protocol for greenwaste movement, strategies, including but not be limited to:

(1) Not moving any greenwaste off of sites where the invasive species has been identified;
(2) Developing county-level lists of invasive species that may be moved in greenwaste;
(3) Developing treatment protocols for each priority species that will be carried out by the agency generating or transporting the greenwaste prior to the waste being moved off site;
(4) Developing maps for species that may be moved locally via greenwaste and monitoring protocols for all regularly used greenwaste recipient sites for all county-level priority species;
(5) Identifying the party responsible for treating new infestations when priority invasive species are identified at the recipient sites;
(6) Prohibiting state or county agencies from authorizing, funding, or carrying out any action that would likely cause or promote the introduction or spread of coqui frogs and other invasive species in Hawaii or to other states, territories, or Pacific islands; and
(7) Requiring all state and county agencies to consider interdiction issues when planning any activity that may cause the accidental introduction of coqui frogs and other invasive species to uninfested areas in Hawaii, other states, territories, or Pacific islands; and

Report on the feasibility of installing intraisland and interisland treatment facilities for agricultural products, and include a budget, to provide a tool to prevent the movement of coqui frogs and other invasive species

Action: DOA is building two hot water treatment facilities at Honolulu and at Hilo.

From the University of Hawaii's (UH) College of Tropical Agriculture and Human Resources website on coqui control:

> "Hot water (49°C [120°F] for 12 minutes) has long been used as an effective treatment against insects of quarantine significance on cut flowers and potted plants. The DLNR Division of Forestry and Wildlife tree nursery in Hilo and an

agricultural engineer from the University of Hawai'i at Hilo designed and built a hot water treatment facility and did some testing to determine the lowest possible lethal temperature for frogs that would also reduce incidence of heat damage to treated plants.

Results indicated that a 45°C (113°F) treatment for 3 minutes was adequate for killing frogs and their eggs. Applied as a shower, this hot water treatment has been effective on frogs and eggs in potted and landscape plants. Heat damage to plants was reduced or eliminated by following the hot water shower with 1-2 minutes of cool water. Orchids and bromeliads were the only plants tested that were sensitive to the treatment. Coqui frog eggs directly dipped in hot water for 3 minutes had a lower rate of hatching compared to untreated eggs of the same age."

This technology has been translated up to large cargo containers that have recently been purchased by the HDOA and are in the process of being installed in Honolulu and Hilo for the purpose of treating commodities believed to be infested with coqui. No information was available at the time this report was submitted on the overall budget or cost to run the facilities."

***Action:* HISC Research and Technology Grant Project with Bill Durston, owner of Leilani Nursery in Waimanalo.**

Project outline from the Contract:
1) Develop an improved coqui shower box as a thermal treatment system for the elimination of coqui frogs and eggs and other plant pests associated with nursery stock.
2) Make design changes that improve spray penetration to speed the uniform temperature rise of materials in the shower box.
3) Make design changes that eliminate the heat sink that evolves from the pooling of water on the floor.
4) Make design changes that decrease the large amounts of water and heat wasted as treatment effluent is evacuated from the system.
5) Test the thermal treatment effectiveness on other species such as red fire ant, papaya mealy bug, and glassy-winged sharpshooter.
6) Estimate the cost savings of the recovery system by estimating the fraction of heat recovered at the boiler point.
7) Project the cost savings of the improved design under commercial operation and estimate return on investment so that potential users can better estimate operation costs.
8) Make the system and its design non-proprietary and available to other nurseries.
9) Communicate results and demonstrate the system directly to nursery industry participants, agency staff, key decision-makers, and legislators at the request ofHISC.
10) Deliver a written progress report on or before October 1, 2005, either electronically or in hard copy. The report must document progress in the nine tasks listed above.
11) Deliver a final written report upon completion of the project, either electronically or in hard copy. The report must document completion of the ten tasks listed above.

Summary of results (excerpt from the final project report that is available on request):

> "We designed and tested new concepts in a commercial scale hot water treatment chamber that eliminates coqui frog and their eggs from potted nursery plants. New design features included:
> a) Recovering heated water leaving the treatment chamber
> b) Fine filtration of recycled water
> c) u.v. sterilization of recycled water
> d) Elimination of storing large volumes of pre-heated water prior to treatment
> We constructed a 20' X 8' X 8' chamber fitted with equipment and controls to meet these design features and then tested its performance with commercial scale loads of nursery plants.
>
> The heating, water recycling, heat recovery, fine filtration, water delivery system and heat characteristics within the chamber and treated plants worked well and met specifications to kill coqui frog on potted nursery plants. Our design was able to deliver 35 gpm of 120 F water into the treatment chamber through 48 cone nozzles that produced reasonably uniform heating of the plants and medium. Heat recovery from recycling the treatment water averaged 81%. This represents an energy savings of nearly 600,000 Btu per hour of operation. With the boilers employed in our design the recycling system saves approximately $10 of propane per hour of operation.
>
> We were unable to sterilize the recycled water with u.v. light. This is because as the hot water treatment progressed, the heated water became colored by soluble substances (probably polyphenolic compounds) leached from the peat moss based medium and u.v. transmission in the u.v. treatment chamber fell to levels well below efficacy. Since peat is the medium of choice for most growers this problem likely eliminates the possibility of sterilizing water as it is recycled during treatment operations.
>
> Following is a presentation and discussion of all aspects of the design, construction, operation and performance of this hot water treatment chamber.
>
> 2) Recommended design changes.
> a) Eliminate u.v. sterilization or install u.v. equipment made to treat highly colored water e.g. equipment used to sterilize maple syrup or tertiary effluent.
> b) Increase opening in gravity filter from 200 mesh to 80 mesh.
> c) Reduce forward momentum of water at the recycled water outfall onto the 200 mesh screen. A plenum that drops water more vertically and spreads it widely onto the screen will reduce water loss when screen begins to plug.
> d) Eliminate bag filter or increase its pore size from 1.0 uM to 100 uM to reduce frequency of bag changes.
> e) Reduce volume of catchment reservoir and use a reservoir shape that is conical or has a sump on the bottom. This change will reduce cavitation at the pump intake.

3) Design evolution toward a commercial scale hot water treatment facility.

a) Laboratory scale.

A small laboratory scale treatment unit was constructed at the Waiakea Research Station to evaluate the effectiveness of a hot water shower treatment to kill frogs on multiple potted plants. The initial treatment system used a small on-demand boiler to heat a large quantity of water held in a tank. The water was circulated between the holding tank and boiler with a pump until it reached the target temperature. Then, the heated water was pumped onto the plants in the experimental chamber via spray nozzles. The entire reservoir of heated water was pumped into the chamber and immediately drained from the chamber floor to waste.

b) Pilot scale of a commercial hot water treatment unit.

With support from Leilani Nursery in Waimanalo we modified the laboratory concept and built a more commercial scale prototype. The treatment chamber was 8' X 10' with a floor lined with vinyl sheeting. The unit was designed to deliver 14 gpm of water into the chamber at 120 F. We eliminated the hot water reservoir by installing a two 199,000 btu/hour on-demand boilers that were plumbed in parallel. Each boiler could raise the temperature of approximately seven gallons of water per minute from 70 F to 120 F and deliver the heated water directly to the spray nozzle system in the treatment chamber. Various nozzle types and their configuration were tested in this phase to overcome problems with spray distribution when large numbers of plants were in the chamber and their foliage was close to the chamber walls. Industrial spray nozzles with a 120 degree cone pattern and spacing on 2' centers along the sides and ceiling were determined to be the most effective. During this phase of development a data logger with a thermocouple was used that could reach various parts of the chamber, plants and potted medium during operation. In this way we determined where the thermocouple needed to be placed to ensure the entire load of plants met temperature and time criteria for killing the frog and its eggs. Heated water from this prototype chamber was also drained to waste. Eliminating the reservoir in favor of larger boiler capacity was more efficient for commercial use than the laboratory design since the operator did not have to wait until the reservoir water was raised to the target temperature to begin a new treatment cycle and avoided the need to retreat a load in case the heated reservoir water was not sufficient to meet the temperature and time specifications for effective treatment.

c) Commercial scale design – this project.

With a grant of $22,675 from the Hawaii Department of Land and Natural Resources (S-05-314-522) through the Hawaii Invasive Species Council and a cost share from Leilani Nursery of $28,500 we designed, constructed and tested a 8' X 8' X 20' commercial prototype hot water treatment facility.

Discussion with growers, the Hawaii Department of Agriculture and experience with the two previous designs led to a new design approach that is documented below with comments and reasoning for selected features. Our design aimed to

reduce operating costs and reduce the potential of spreading disease between plants.

Prominent features of the new design include:
1) Recycling heated water after it passes through the hot water chamber.
2) Fine filtration of recycled water including 73 and 1.0 micron filtration
3) Sterilization of recycled water by ultraviolet light treatment.
4) Pressure, temperature and flow monitors in the supply and return portions of the water delivery and recovery systems

We tested the performance of the system and system components under commercial scale product throughput. Following the design description below we provide a detailed account of the system's performance, its operation and propose design changes to the system.

Based on this report the cost to build a similar unit without the UV sterilizer:

Materials	$18,776
Labor	$ 8,900
Total building costs	$27,626

Annual costs to operate (utilities include water, gas and electrical charges):

Utilities	$38,040
Materials (repairs)	$ 1,500
Dedicated technician	$42,000
Total annual operating costs	$81,540

Total cost to build and operate for one year: $109,166

The feasibility of constructing similar units for the purpose of treating any material potentially infested with coqui frogs by providing grants to encourage private operators, or providing space for either agency operated or concession run operations is very good.

The efficacy of this treatment on other pests is the subject on ongoing research. Preliminary results show that higher temperatures may be needed to treat for other invertebrate pests and the time the plants are exposed to the treatment may need to be increased. This has a negative effect on some of the plant species that are more temperature sensitive. The CTAHR is continuing to test for the range of pests that can be controlled by a temperature and time combination that is least damaging to a wide range of plants. This treatment be unlikely to effect viral diseases of plants and should not be a substitute for interisland quarantine inspections. In general, as

a tool to reduce the risk of spreading invasive species between islands this technology is very promising and should be supported."

Research and report on the information gathered from case studies and economic analyses conducted by the United States Department of Agriculture's T-STAR program and other applicable studies

Action: Summary of Research Results.
A) T-Star Program.
The T-STAR projects, or the "Economics of Managing Invasive Species in Tropical and Sub-Tropical Areas of the U.S. Hawaii" project is a cross-regional collaborative endeavor between the University of Hawaii and the Universities of Guam, Florida, and Puerto Rico. These institutions represent the Pacific Basin and Caribbean Basin regions of T-STAR (Tropical/Subtropical Agriculture Research), a special grant program administered by the U.S. Dept. of Agriculture.

The overall goal of the project is to enhance the decision-making capabilities of public and private sector managers involved with invasions by alien species. The main objective is development of a comprehensive framework and modeling system that integrates the biological profile of a pest species with economic information to evaluate the potential damages from invasion and impacts of alternative management decisions. A secondary objective is to develop a collaborative interdisciplinary network of institutions and resource persons active in invasive species management.

The specific problem addressed by this project is the absence of a comprehensive pest risk management system that combines economics and scientific analyses into a single decision-making framework. Such a system is needed by decision-makers like government leaders, agency technical staff, managers of public and private lands, private firms/producers, and scientists, to determine how best to manage the risks of pest introduction and/or spread in a manner that minimizes overall damages. An effective decision system would:

- Provide a consistent approach to analyzing invasive species problems
- Be useful for a range of pests, economic impacts, and management responses
- Incorporate different risk attitudes, gaps in information and other uncertainties
- Identify tradeoffs in pursuing different management strategies and control interventions
- Guide questions and interactions between specialists from different scientific fields
- Facilitate exchange of information and experiences between groups involved with managing biological invasions
- Be compatible with international trade agreements.

The preliminary conclusions of the T-STAR economics of invasive species grants that were initiated in 2003 are now being published. A sampling of the articles related to this project and selected summaries are presented below. A comprehensive review is not

available at this time and a more detailed summary will be presented as the studies are finalized next year.

B) Department of Economics, UH
Research and report on the information gathered from case studies and economic analyses conducted by the Department of Economics at the UH

A research team funded by USDA's Economic Research Program (Cooperative agreement number 43-3AEM-3-80083, Principal Investigator: James Roumasset, Co-PI Brooks Kaiser) and the United States Fish and Wildlife Service (Cooperative agreement number 122005G005, Principal Investigator: James Roumasset) is investigating the economic consequences for several of Hawaii's invasive species, including the brown treesnake, miconia, and the coqui frog. Some preliminary results and publications from this initiative follow.

Burnett, K. 2006. "Introduction of Invasive Species: Failure of the Weaker Link." *Agricultural Resource Economics Review* 35(1): 21-28.

Burnett, K., B. Kaiser, B. Pitafi, and J. Roumasset. 2006. "Prevention, Eradication, and Containment of Invasive Species: Illustrations from Hawaii," *Agricultural and Resource Economics Review* 35(1): 63-77.

Kaiser, B., K. Burnett, and J. Roumasset. 2006. "Economic Lessons from Control Efforts for an Invasive Species: *Miconia calvescens* in Hawaii," forthcoming in *Journal of Forest Economics*.

Kaiser, B. and K. Burnett. 2006. "Economic Impacts of E. Coqui Frogs in Hawaii," forthcoming in *Interdisciplinary Environmental Review*.

Kasier, B., B. Pitafi, J. Roumasset, and K. Burnett. 2006. The Economic Value of Watershed Conservation," forthcoming in *Land Management Impacts on Coastal Watershed Hydrology* (eds. A. Fares and A. El-Kadi). WIT Press, Southampton, U.K.

1. Initial results for the impact of coqui on real estate:
   Eleutherodactylus coqui, a small frog native to Puerto Rico, was introduced to Hawaii in the late 1980s, presumably as a hitchhiker on plant material from the Caribbean or Florida. The severity of the frogs' songs on the island of Hawaii has lead to a hypothesis touted both in the scientific community and in the popular media that the presence of the frog on or near a property results in a decline in that property's value. The objective of this study is to measure the direct damage costs of the coqui's loud mating songs through a hedonic pricing model. Because this only one component of the economic costs of noise pollution, it should be considered a lower bound estimate of the true cost of their noise and their presence. We find that coqui frogs do impose localized damages to real estate values, but by 800 meters distance from a complaint this damage is declining relative to the effect at 500m. The per-transaction reduction in value when frog complaints have been lodged within 500m appears to be about

0.16%, holding constant district, acreage, financial conditions, zoning, and neighborhood characteristics.

If the coqui frog spreads across all residential properties, direct damages to property values are estimated at a minimum of $7.6 million. With annual sales values of $50.5 million in floriculture and nursery products a loss of 0.16% per annum results in another $81,000 in losses per year for the county.

Again, this must be considered a very lower bound on actual damages as the analysis does not yet include losses in sales to nurseries, the potential cost increase to nurseries to become certified "frog free," or any ecological impacts. For example, if the presence of the frog leads to even a 1% increase in probability of brown treesnake viability this increases damages by $1.8 million.

2. Initial results for optimized control of miconia:
   The case of *Miconia* is used to illustrate dynamic policy options for forest invasive species that are already present in an ecosystem. Hawaii's forest ecosystems provide direct and indirect ecosystem services, with high expected value generated from the preservation of existing ecosystem conditions stemming from unique biodiversity assets. *Miconia* generates concerns that extend from biodiversity to infrastructure for water supply as it threatens moist tropical island watersheds and forest ecosystems. Using optimal control, we define our problem so that we minimize the expected costs and damages from the presence of and control activities undertaken against the invading species.

   Optimal policy calls for population reduction on the islands of Oahu, Maui, and Hawaii, population expansion on Kauai, and continued prevention on Molokai. Differences in steady state populations are mainly the result of variations in search costs and potential habitats. For example, the population on Kauai is currently "too insignificant," that is, the high search cost calls for waiting until the population is larger to invest in harvesting. Although the present value damage per tree is substantial, it does not outweigh the magnitude of the search component of control at the low population. On the island of Oahu, however, ease of access to *Miconia* habitat is facilitated by the comparatively large amount of roads and trails on the island. Furthermore, the search cost on Oahu is almost half that of Kauai (due to fewer potential acres of habitat). Maui and Hawaii have lower per unit expected damages than Oahu, and higher search costs due to both greater amounts of habitat and more difficult access. While optimal populations are higher than Oahu and Kauai, significant reductions of the Maui and Hawaii populations are preferred to the current state. For the island of Molokai, where no trees are currently believed present, annual monitoring expenditures should be continued. If this prevention fails and a population establishes on the island, we find a low steady state population of trees is preferred to eradication.

   Initial results for the reduction for brown treesnakes:

The threat of invasive species stems from their ability to rapidly and irreversibly change ecosystems and the direct and indirect economic services that ecosystems provide. Each of several stages of invasion dictates different human response. In general, policy makers must determine the proper balance between "prevention" expenditures that lower the probability of new introductions and "control" expenditures that limit the growth rate and/or the species population. Optimal policy regarding invasive species will minimize the expected damages and costs of control within an ecosystem and will include full consideration of the cycle of prevention (or avoidance) and control (or removals) needed over time. Rarely, however, have policy makers or economists integrated prevention and control for optimal intertemporal allocation of resources.

We illuminate theoretically how expenditure paths change in response to various biological and economic parameters, and solve for expenditures for every population level and each time period for the real-world case of the Brown Treesnake (BTS). We find that the conventional wisdom that "an ounce of prevention is worth a pound of cure" does not reveal the whole story. Depending on the interaction of biology and economics, the message may be much richer than this. In particular, the dynamics of prevention and control interact in such a way that it pays to increase control, even at the expense of foregone prevention expenditures, at very low populations.